5 Chemistry in industry

Charges, chemical formulae and equations

Question	Answers and guidance	Marks
1 a)	Carbon dioxide Oxygen is formed that reacts with the hot carbon electrode	1 1
b) i)	$Al^{3+} + 3e^- \rightarrow Al$	1
ii)	$2O^{2-} \rightarrow O_2 + 4e^-$	1
c)	3 faradays	1
Total		**5**

Question	Answers and guidance	Marks
2 a)	Iron is low/below carbon in the reactivity series Using carbon is cheaper than electricity	1 1
b)	$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$ 1 mark for correct formulae; 1 mark for correct balancing	2
c)	Limestone is used to remove impurities/make slag which contains impurities Coke provides both fuel and the carbon needed Air provides oxygen to help the coke to burn well	1 1 1
d)	Carbon is cheap/easily obtained Carbon dioxide is a greenhouse gas	1 1
Total		**9**

Question	Answers and guidance	Marks
3 a)	$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$ 1 mark for correct formulae; 1 mark for correct balancing	2
b)	$2ZnO + C \rightarrow 2Zn + CO_2$ 1 mark for correct formulae; 1 mark for correct balancing	2
c)	Makes sulfur dioxide which makes acid rain; capture sulfur dioxide gas Makes carbon dioxide, a greenhouse gas; capture the carbon dioxide	1 1 1 1
d)	Zinc is low/below carbon in the reactivity series	1
Total		**9**

Question	Answers and guidance	Marks
4 a)	$Al_2O_3 + 6Na \rightarrow 2Al + 3Na_2O$ 1 mark for correct formulae; 1 mark for correct balancing	1 1
b)	You need six sodium ions for every aluminium oxide/for every two atoms of aluminium made	1 1
c)	Aluminium is a reactive metal/above carbon in the reactivity series	1
d)	Aluminium oxide has a high melting point (3000 °C)/the cryolite mixture only needs a temperature of 950 °C This reduces the cost of the energy needed	1 1
e) i)	Al^{3+}	1
ii)	O^{2-}	1
f) i)	$Al^{3+} + 3e^- \rightarrow Al$	1
ii)	$2O^{2-} \rightarrow O_2 + 4e^-$	1
g)	You need three electrons for every atom of aluminium made This comes from electricity which is very expensive	1 1 1
Total		**14**

Question	Answers and guidance	Marks
5 a) i)	Na^+	1
ii)	Cl^-	1
b) i)	$Na^+ + e^- \rightarrow Na$	1
ii)	$2Cl^- \rightarrow Cl_2 + 2e^-$	1
c)	Na = 23, so $\frac{46}{23} = 2$ mol Na Each mole requires 1 faraday, so = 2 × 1 = 2 faradays	1 1
d)	Sodium – avoid getting the apparatus wet. Chlorine – carry out in fume cupboard/wear gas mask	1 1
Total		**8**

Practical work

Question	Answers and guidance	Marks
1 a)	Green	1
b) i)	Bubbles of gas/solution being bleached	1
ii)	Hydrogen	1
c)	The solution is becoming alkaline Sodium hydroxide/hydroxide ion	1 1
d)	Chlorine gas	1
Total		**6**

Question	Answers and guidance	Marks
2 a)	Sodium chloride solution	1
b) i)	Chlorine	1
ii)	Pass gas across wet litmus/universal indicator paper The paper will be bleached	1 1
c) i)	Sodium hydroxide	1
ii)	$2H^+ + 2e^- \rightarrow H_2$	1
iii)	Add a burning spill. It should burn with a 'pop'	1
d)	To separate the chlorine and hydrogen gases So they cannot react with each other	1 1
Total		**9**

Question	Answers and guidance	Marks
3 a)	Hydrogen Add a burning spill. It should burn with a 'pop'	1 1
b) i)	Put a glowing spill in the gas. It should re-light	1
ii)	$4OH^- - 4e^- \rightarrow 2H_2O + O_2$	1
c)	Find the boiling point of the liquid It will be water if the boiling point is 100 °C	1 1
Total		**6**

Question	Answers and guidance	Marks
4 a) i)	Pass gas across wet litmus/universal indicator paper The paper will be bleached	1 1
ii)	$2Cl^- \rightarrow Cl_2 + 2e^-$	1
b)	Add a burning spill. It should burn with a 'pop'	1
c) i)	The sodium metal that is made immediately reacts with water/ making sodium hydroxide and hydrogen gas OR Sodium is very high in the reactivity series so hydrogen is preferentially discharged	1 1 OR 1 1
ii)	$2Na + 2H_2O \rightarrow 2NaOH + H_2$ 1 mark for correct formulae; 1 mark for correct balancing	2
d)	Sodium hydroxide: bleach/making soap/making paper Chlorine: use in plastics/water purification/making bleach/hydrochloric acid	1 1
Total		**10**

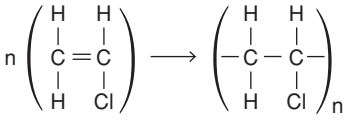
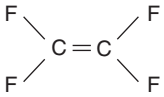
<table>
<tr><th>Question</th><th>Answers</th><th>Marks</th></tr>
<tr><td>5 a)</td><td>
<table>
<tr><td></td><td>at the start of the experiment</td><td>during the experiment</td><td>at the end of the experiment</td></tr>
<tr><td>colour of solution in the centre of the Petri dish</td><td>red</td><td>red</td><td>red</td></tr>
<tr><td>observations around the positive electrode</td><td>none</td><td>starting to go colourless</td><td>bleached colourless</td></tr>
<tr><td>observations around the negative electrode</td><td>none</td><td>changing from red to blue</td><td>turned blue</td></tr>
<tr><td>other observations</td><td>none</td><td>slight smell of chlorine</td><td>strong smell of chlorine</td></tr>
</table>
1 mark for each complete line across
</td><td>1
1
1</td></tr>
<tr><td>b)</td><td>chlorine gas is produced at the positive electrode</td><td>1</td></tr>
<tr><td>c)</td><td>$2Cl^- \rightarrow Cl_2 + 2e^-$</td><td>1</td></tr>
<tr><td>d)</td><td>The sodium metal that is made immediately reacts with water
making sodium hydroxide and hydrogen gas</td><td>1
1</td></tr>
<tr><td>e)</td><td>Add a burning spill. It should burn with a ‘pop’</td><td>1</td></tr>
<tr><td>f)</td><td>Carry out in fume cupboard/wear gas mask/wear gloves</td><td>1</td></tr>
<tr><td>Total</td><td></td><td>9</td></tr>
</table>

Question	Answers and guidance	Marks
6 a)	$Cu^{2+} + 2e^- \rightarrow Cu$	1
b) i)	Oxygen	1
ii)	$4OH^- - 4e^- \rightarrow 2H_2O + O_2$	1
c)	They are very unreactive (inert)	1
d)	For each electron, $\frac{0.635}{63.5} = 0.01$ faradays Each mole needs 2 faradays So this is $0.01 \times 2 = 0.02$ faradays	1 1 1
e) i)	0.25 faradays makes $\frac{0.25}{2}$ moles of Cl_2 gas = 0.125 mol	1
ii)	$35.5 \times 2 = 71$ (*Mr* Cl_2 gas) $0.125 \times 71 = 8.875$ g	1 1
Total		**10**

Data analysis

Question	Answers and guidance	Marks
1 a)	Fractions contain a mixture of molecules that have a similar number of carbon atoms	1 1
b)	As the average number of carbon atoms increases the average boiling point increases	 1
c)	It has long chains of carbon atoms that tangle together OR The boiling point is high which means there are strong forces holding the molecules together	1 1
d)	Bitumen As the trend in the table shows the larger the number of carbons the greater the difficulty/ length of time to ignite	1 1
Total		**7**

Question	Answers and guidance	Marks
2 a) i)	Soot/carbon	1
ii)	There was not enough air/oxygen	1
b)	As the number of carbon atoms increases the mass of carbon/soot increases	1 1
c)	Kerosene The value is to one decimal place, the others are to two	1 1
d)	Carbon dioxide Water	1 1
e)	Carbon monoxide can be formed which is absorbed by the blood/haemoglobin instead of oxygen/poisonous	1 1
Total		**10**

Question	Answers and guidance	Marks
3 a)	Each small/ethene/monomer molecule has a double bond that can break The small/ethene/monomer molecules then join together to form a long chain	1 1
b)	A hydrogen atom has been replaced by a chlorine atom	1
c)	 1 mark 1 mark	2
d)		1
e)	Polytetra(fluoroethene)	1
f)	They are inert so they do not decompose/biodegrade easily	1 1
Total		**9**

Question	Answers and guidance	Marks
4 a)	Small molecule that joins together to form polymers	1
b)	Poly(ethene): plastic bags/bottles Poly(propene): fibres/ropes Poly(chloroethene): rainwater guttering/clothes	1 1 1
c)	Every bond made produces a water molecule that condense together to make water	 1
d)	Nylon/polyester/polyamide	1
Total		**6**

Question	Answers and guidance	Marks
5 a)	Gasoline and diesel	1
b)	Not all the fractions have been included	1
c)	The breaking of larger molecules down into smaller ones	1 1
d)	Lubricating oil and fuel oil	1
e)	$C_{20}H_{42} \rightarrow C_{18}H_{38} + C_2H_4$ 1 mark for correct formulae; 1 mark for balanced equation	2
Total		**7**

Working with graphs

Question	Answers and guidance	Marks
1 a) i)	63%	1
ii)	Increases the amount of ammonia made ***One*** *reason from:* • you can see on the graph that as the pressure rises the % ammonia made increases • in gas reactions increasing pressure leads to reduction in number of molecules, so reaction has less molecules on right, than left/4 molecules become 2	1 1
b)	Increasing temperature reduces yield Higher temperature favours the endothermic reaction breaking ammonia back to nitrogen and hydrogen An exothermic reaction needs to lose energy and at higher temperatures this is harder to achieve	1 1 1
c)	An explanation linking four of the following points for 1 mark each: • increasing temperature reduces the % of ammonia formed • increasing temperature favours backward reaction • increasing pressure makes more ammonia • favours forward reaction as number of moles (volume) of products is less than reactants. • rate of reaction is more important than yield • percentage yield does not matter as all the unreacted gases are recycled and become ammonia eventually	4
Total		**10**

Question	Answers and guidance	Marks
2 a) i)	Vanadium oxide	1
ii)	To speed up/alter the rate of the reaction	1
iii)	Reversible reaction	1
b) i)	92%	1
ii)	96% The reaction takes place quickly The catalyst speeds up the reaction allowing equilibrium to be reached	1 1 1 1
iii)	Increasing the temperature reduces the yield *Reasons* As higher temperature favours the endothermic/backward reaction) An exothermic reaction needs to lose energy, and at higher temperatures this is harder to achieve	1 1 1
Total		**11**

Question	Answers and guidance	Marks
3 a) i)	Any **four** for 1 mark each from: • at first the pH remained the same at 12 • until at 24 cm^3 added • it dropped rapidly • before reaching 1 at 40 cm^3 • continued at 1 up to 50 cm^3	4
ii)	25 cm^3 *Reason* This is the neutral point/pH 7 OR There are equal quantities of sulfuric acid and ammonium hydroxide at this volume	1 1
b)	Any **four** points for 1 mark each from: • for every 50 cm^3 of ammonium hydroxide • 25 cm^3 of sulfuric acid should be added. • the solution should be evaporated • to one-third the volume • the crystals obtained should be filtered from the solution	4
c)	The molarities must be the same	1
Total		**11**

Question	Answers and guidance	Marks
4 a)	A reaction where the forward reaction has the same rate as the backward reaction. The concentrations of products and reactants do not change	2
b)	Nitrogen comes from the air Hydrogen is obtained from methane/natural gas	1 1
c) i)	28%	1
ii)	An explanation linking **four** points from: • catalyst speeds up the forward reaction • low temperature favours the forward reaction • high pressure speeds up the forward reaction • comment on costs of high temperature or pressure • comment suggesting need to compromise maximum yield in favour of speed of reaction.	4
Total		**9**

Question	Answers and guidance	Marks
5 a) i)	30 °C	1
ii)	13%	1
iii)	3 days	1
b)	An explanation linking **four** points for 1 mark each from: • the rate is higher at 40 °C than at 30 °C • at 55 °C there is (effectively) no ethanol produced • most ethanol is produced at 30 °C • making the ethanol at 30 °C takes 24 hours longer A concluding statement must be present to gain 4 marks	4
Total		**7**

Calculations

Question	Answers	Marks
1 a)	40 + 12 + 16 + 16 + 16 = 100 g	1 1
b)	Reacting ratio 1 : 1 So 2 mol produced $2 \times 24\ dm^3 = 48\ dm^3$	1 1 1
c)	$\frac{125}{100} = 1.25$ mol $1.25 \times 56 \times 1$ = 70 tonnes	1 1 1
d)	$\frac{55}{70} \times 100$ = 78.6%	1 1
Total		**10**

Question	Answers	Marks
2 a)	0.5 moles	1
b)	14 + 1 + 1 + 1 = 17 g	1 1
c)	$\frac{51}{17} = 3$ mol 3×24 $= 72\ dm^3$	1 1 1
d)	1 : 2 reacting ratio, so 1.5 produces 3 mol of product so $1.5 \times 24 = 36\ dm^3$	1 1
Total		**8**

Question	Answers and guidance	Marks
3 a)	1 + 14 + 16 + 16 + 16 = 63 g	1 1
b)	14 + 1 + 1 + 1 + 1 + 14 + 16 + 16 + 16 = 80	1 1
c) i)	Reacting ratio 1 : 1 So $0.2 \times 80 \times 1$ = 16 g	1 1 1
ii)	$\frac{5.6}{16} \times 100$ = 35%	1 1
Total		**9**

Question	Answers and guidance	Marks
4 a)	Reduction/redox	1
b)	It is an unreactive metal/carbon is higher in the reactivity series	1
c)	56 + 56 + 16 + 16 + 16 =160 g	1 1
d)	12 + 16 + 16 = 44 g	1 1
e) i)	ratio is 2 : 3 $\frac{8}{160} = 0.05$ $0.05 \times 12 \times (3/2) = 0.9$ g	1 1 1
ii)	$0.05 \times (3/2) = 0.075$ mol $0.075 \times 24 = 1.8$ dm^3	1 1
Total		**11**

Question	Answers and guidance	Marks
5 a)	Charge = 2.5 A × (60 × 60) s = 9000 coulombs	1 1
b)	reacting ratio, 2 moles electrons : 1 mole copper $\frac{9000}{2} = 4500$ $\frac{4500}{96500}$ = 0.047 moles of copper	1 1 1
c)	0.047 × 63.5 = 2.98 g	1 1
d) i)	Reacting ratio, 4 moles electron : 1 mole of oxygen gas $\frac{9000}{4} = 2250$ $\frac{2250}{96500} = 0.0233$ mol of oxygen gas OR 4 moles oxygen : 2 moles copper Ratio = 2 : 1 So $\frac{0.047}{2} = 0.0235$ mol	1 1 1
ii)	0.0235 × 24 = 0.564 dm^3	1 1
Total		**12**

Longer-answer questions

Question	Answers and guidance	Marks
1	Sulfur burns with oxygen to make sulfur dioxide/$S + O_2 \rightarrow SO_2$ Sulfur dioxide is reacted with more oxygen to make sulfur trioxide/$2SO_2 + O_2 \rightarrow 2SO_3$ Vanadium oxide catalyst used Reaction carried out at 450 °C 2 atmospheres pressure Sulfur trioxide is dissolved in sulfuric acid to make concentrated sulfuric acid	1 1 1 1 1 1
Total		**6**

Question	Answers and guidance	Marks
2 a)	An explanation linking any **four** of the following for 1 mark each: • crude oil/vapour rises through the (fractionating) column • idea of temperature gradient in column, e.g. hotter at the bottom than at the top • different fractions have different boiling points • condense when they get to the part of the column that has lower temperature than their boiling point • vapour passes through bubble caps/one-way valves OR idea that liquid fractions cannot trickle back down because of bubble caps	4
b)	A description linking the following points for 1 mark each: • long-chain hydrocarbons are heated to 600–700 °C • with a catalyst of silica/alumina • to make alkenes/ethene • a shorter-chain alkane molecule	4
Total		**8**

Question	Answers and guidance	Marks
3 a)	An explanation linking any **four** of the following for 1 mark each: • brine is sodium chloride solution • the unnamed product is hydrogen gas • the diaphragm separates chlorine and hydrogen gas • so they cannot react • the diaphragm does not allow chloride ions through/allows only sodium ions through	4
b)	Sodium hydroxide: bleach/paper/soap Chlorine: sterilising water supplies/making bleach/hydrochloric acid.	1 1
Total		**6**

Question	Answers and guidance	Marks
4 a)	The unreacted nitrogen and hydrogen are recycled So the percentage converted does not matter, as eventually it all will be converted	1 1
b)	A description including **three** of the following points for 1 mark each: • raising the temperature will reduce the ammonia made/increase amount of nitrogen and hydrogen • raising temperature increases the rate of product formation. • raising the pressure will decrease the number of molecules so reaction makes more ammonia • four reactant molecules become two product molecules when pressure raised with linking explanation of conditions chosen, e.g. 450 °C and 200 atm is a compromise that gives reasonable yield (15%), but is quick	3 1
Total		**6**

Question	Answers and guidance	Marks
5 a)	An explanation linking **four** of the following points for 1 mark each: • electrolysis only happens when ions are free to move in solution or molten • aluminium oxide does not dissolve in water • to melt aluminium oxide you need 2040 °C, cryolite only requires 950 °C • reduces energy needed to allow ions to move • so less money will be needed to allow the electrolysis to occur	4
b)	An explanation linking two of the following points: • you need 3 moles/faradays of electrons to make 1 mole of aluminium • you need 2 moles/faradays of electrons to make 1 mole of magnesium • so you need 1.5 times/half as much again more electricity to make a mole of aluminium than magnesium	 1 1
Total		**6**

Question	Answers and guidance	Marks
6	An explanation including **four** of the following points for 1 mark each: • the reaction is an equilibrium /reversible • raising the temperature reduces the ammonia made/increases amount of nitrogen and hydrogen • raising temperature increases the rate of product formation. • raising the pressure will decrease the number of molecules so reaction makes more ammonia • the unreacted nitrogen and hydrogen are recycled • so the percentage converted does not matter, as eventually it all will be converted. With 1 mark for linking explanation of conditions chosen, e.g. 450 °C and 200 atm is a compromise that gives reasonable yield (15%), but is quick	4 1
Total		**5**